CALIFORNIA INSTITUTE OF TECHNOLOGY

Pasadena, California 91125, U.S.A.

Division of Geological and Planetary Sciences
Mail Code: 170-25
email: ems@expet.gps.caltech.edu
Telephone (818) 395-6504
FAX (818) 568-0935

June 6, 1997

Cosmochemistry Program
The Lunar and Planetary Institute
3600 Bay Area Blvd.
Houston, TX 77058

Attn: Joseph Boyce, Grants Officer

Re: Final Technical Report for NASA Grant NAGW-3533
"Experimental studies of phase equilibria of meteorites and planetary interiors."

Dear Joe:

The theme of this project was the application of the principles of phase equilibria and the methodology of experimental petrology to a variety of problems in meteoritics and planetary geology. The goals of these studies were to provide a framework for understanding the petrography of meteorites and their components, to help develop constraints on the histories of the environments in which they formed, and to understand the processes involved in the evolution of igneous rocks on the earth and other planets.

A complete list of the publications resulting from this grant follows. These publications represent the tangible products of this grant and are the basis on which the success of the project in meeting its stated goals should be judged.

Journal Articles:

Barber, D.J., J.R. Beckett, J.M. Paque, and E.M. Stolper (1994) A new titanium-bearing calcium aluminosilicate phase: II. Crystallography and crystal chemistry of grains formed in slowly cooled melts of CAI composition. Meteoritics, **29**, p. 682-690.

Watson, L.L., I.D. Hutcheon, S. Epstein, and E.M. Stolper (1994) Water on Mars: Clues from D/H and water contents of hydrous phases in SNC meteorites. Science, **265**, p. 86-90.

Chamberlin, L., J. Beckett, and E. Stolper (1994) Pd-oxide equilibration: A new experimental method for the direct determination of oxide activities in melts and minerals. Contributions to Mineralogy and Petrology, **116**, p. 169-181.

Paque, J.M., J.R. Beckett, D.J. Barber and E.M. Stolper (1994) A new titanium-bearing calcium aluminosilicate phase: I. Meteoritic occurrences and formation in synthetic systems. Meteoritics, **29**, p. 673-682.

Chamberlin, L., J.R. Beckett, and E. Stolper (1995) Pd-oxide equilibration and the thermodynamic properties of $MgAl_2O_4$ spinel. Amer. Mineral. **80**, p. 285-296.

Leshin, L.A., S. Epstein, and E.M. Stolper (1996) Hydrogen isotope geochemistry of SNC meteorites. Geochim. Cosmochim. Acta, **60**, p. 2635-2650.

Beckett J. R. and Mendybaev R. A. (1997) The measurement of oxygen fugacities in flowing gas mixtures at temperatures below 1200°C. Geochim. Cosmochim. Acta (in press).

Beckett, J.R. and E. Stolper (1997) The partitioning of Na between melilite and liquid: An experimental study with application to type B inclusions from carbonaceous chondrites. Geochim. Cosmochim. Acta (submitted).

Chamberlin, L., J.R. Beckett, and E. Stolper (1997) Experimental measurement of oxide activities across the join $MgAl_2O_4$-$Al_{8/3}O_4$ at 1400°C. Amer. Mineral. (submitted).

Chamberlin, L. J.R. Beckett, and E. Stolper (1997) Thermodynamic properties of dilute solutions of Mg, Al, and Si in Pd metal. J. Alloys Compounds (submitted).

Kennedy A.K., J.R. Beckett, D.A. Edwards, and I.D. Hutcheon (1997) Trace element disequilibria and magnesium isotope heterogeneity in 3655A: Evidence for a complex multi-stage evollution of a typical Allende Type B1 CAI. Geochim. Cosmochim. Acta, **61**, p. 1541-1561.

Mendybaev, R.A., J.R. Beckett, E. Stolper, and L. Grossman (1997) Measurement of oxygen fugacities under extremely reducing conditions: non-Nernstian behavior of a Y_2O_3-doped zirconia oxygen sensor. Geochim. Cosmochim. Acta (submitted).

Valley J. W., Eiler J. M., Graham C. M., Gibson E. K., Romanek C. S., and Stolper E. M. (1997) Low-temperature carbonate concretions in the Martian meteorite ALH84001: Evidence from stable isotopes and mineralogy. Science **275**, 1633-1638.

Abstracts:

Watson, L.L., S. Epstein, and E.M. Stolper (1994) The abundance and stable isotopic composition of volatiles released from weathering products during stepped heating of Nakhla and Lafayette. Lunar Planet. Sci., **XXV**, p. 1471-1472.

Watson, L.L., S. Epstein, and E. Stolper (1994) D/H of water released by step heating of Shergotty, Zagami, Chassigny, ALH84001 and Nakhla. Meteoritics **29**, 547.

Leshin, L.A., S. Epstein, and E. Stolper (1995) The abundance and D/H of water dissolved in EETA shocked glass and crystalline host. Lunar Planet. Sci., **XXVI**, 839-840.

Mendybaev, R.A., J.R. Beckett, L. Grossman, E. Stolper, R.F. Cooper, and J.P. Bradley (1995) Evaporation rate of silicon carbide in reducing gases. Lunar Planet. Sci., **XXVI**, 955-956.

Newman, S., J. Beckett, N. Bashir, and E. Stolper (1995) Water in an indochinite: Implications for the thermal history of tektites. Lunar Planet. Sci., **XXVI**, 1039-1040.

Stolper, L. Leshin, I.D. Hutcheon, and S. Epstein, 1995, Water on Mars: Clues from the D:H ratios of SNC meteorites. Silver Retirement Symposium, Pasadena, California, p. 173.

Bashir, N., J.R. Beckett, I.D. Hutcheon, and E.M. Stolper (1996) Carbon in the metal of iron meteorites. Lunar Planet. Sci., **XXVII**, p. 63-64.

Leshin, L., S. Epstein, and E.M Stolper, 1996, Hydrogen isotope geochemistry of SNC (Martian) meteorites and the history of water on Mars. Workshop on the Evolution of Martian Volatiles, LPI Technical Report.

Mendybaev, R.A., J.R. Beckett, L. Grossman, and E. Stolper (1996) Kinetics and mechanisms of volatilization of SiC and SiO_2 in the solar nebula. Lunar Planet. Sci., **XXVII**, p. 865-866.

Eiler J. M., Valley J. W., and Stolper E. M. (1997) Stable isotopes in ALH84001: An ion microprobe study. Meteoritics and Planetary Science (submitted).

Mendybaev R. A., Beckett J. R., Stolper E., and Grossman L. (1997) Volatilization of graphite in reducing gases: Preliminary results. Lunar Planet. Sci., **XXVIII** (in press).

Newman S., Beckett J., and Stolper E. (1997) 3-D variations of water in an indochinite. Lunar Planet. Sci., **XXVIII**, 1017-1018.

Valley J. W., Eiler J. M., Graham C. M., Gibson E. K., and Romanek C. S. (1997) Ion microprobe analysis of oxygen and carbon isotope ratios in the ALH84001 meteorite. Lunar Planet. Sci., **XXVIII**, 1475-1476.

Please let me know if you need any further information to "close the file" on this project.

Sincerely,

Ed Stolper

Edward Stolper
William E. Leonhard Professor of Geology and
Chairman of the Division of Geological and
Planetary Sciences

cc: D. Nava, Technical Officer
NASA CASI